METHODS AND APPARATUS FOR CATALYTIC HYDROTHERMAL GASIFICATION OF BIOMASS

PRIORITY

This invention claims priority from U.S. Provisional Patent Application 61/024,970 filed Jan. 31, 2008, which application is incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with Government support under Contract DE-AC0576RL01830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

BACKGROUND

Gasification of biomass by thermal methods involving pyrolysis and/or partial oxidation is known as a method to produce a synthesis gas, composed of carbon oxides and hydrogen, or a fuel gas. Many of the known methods use a dry biomass feedstock with less than 10 wt % moisture. However, much of the biomass resource contains higher levels of moisture, more typically 50 wt % and some even consist of wet biomass, or biomass in water slurries at 85 wt % moisture or higher. One approach to efficiently process such wet biomass is gasification employing an active catalyst in a pressurized water environment (e.g., hydrothermal gasification).

However, when treating wet biomass by hydrothermal gasification, constituents that are commonly inherent in the feedstock can poison and/or foul the catalyst making long-term and/or continuous operation difficult to achieve. Accordingly, a need for apparatuses and methods for hydrothermal gasification of wet biomass exist.

SUMMARY

The present invention includes apparatuses and methods for treating wet biomass by catalytic hydrothermal gasification that address the problem of poisoning and fouling of the catalyst, especially for long-term and/or continuous use. Unexpectedly, the inorganic wastes that precipitate in the catalyst and cause plugging and poisoning can be precipitated by heating the wet biomass feedstock prior to exposure to the catalyst. Accordingly, treatment of the wet biomass feedstock comprises heating the wet biomass with a heating unit to a temperature sufficient for organic constituents in the feedstock to decompose, for precipitates of inorganic wastes to form, for preheating the wet feedstock in preparation for subsequent separation of sulfur contaminants, or combinations thereof. Treatment further comprises separating the precipitates out of the wet feedstock, removing sulfur contaminants, or both using a solids separation unit and a sulfur separation unit, respectively. Having removed much of the inorganic wastes and the sulfur that can cause poisoning and fouling, the wet biomass feedstock can be exposed to the heterogeneous catalyst for gasification.

As used herein, biomass refers to biological material that can be used for fuel or for industrial production. Exemplary biomass can include, but is not limited to, biosludge from wastewater treatment facilities, sewage sludge from municipal treatment systems, wet byproducts from biorefinery operations, wet byproducts/residues from food processing, animal waste and waste from centralized animal raising facilities, organic chemical manufacturing wastewater streams, and industrial wastewater containing organics. Biomass commonly comprises organic matter that can be treated in a continuous reactor, according to embodiments of the present invention, to yield a gas containing hydrogen or useful for hydrogen production (e.g., methane). Common inorganic contaminants, which can poison and/or foul the catalyst, can include, but are not limited to minerals comprising Ca, Mg, P, and/or Fe.

In preferred embodiments, the heterogeneous catalysts comprise Ru, Ni, and/or Ni with added Na. The Na can be in the form of a sodium carbonate co-catalyst. In a particular embodiment, the catalyst comprises Ru on a carbon support. Furthermore, the catalyst can be configured to gasify the organic constituents into a hydrogen-containing feedstock for subsequent catalytic reformation.

Separation of solids from the heated wet biomass feedstock can be achieved using a solids separation unit, which can include, but is not limited to, a gravity separation unit, a hydrocyclonic separation unit, and/or a filtration unit. Removal of sulfur can be achieved using a sulfur separation unit comprising, for example, an adsorbent bed with a metal or metal oxide.

Preferably, the catalytic hydrothermal gasification occurs at conditions in which water is below its critical point (i.e., sub-critical). In a particular embodiment, the wet biomass feedstock is heated to at least 300° C. In another embodiment, a catalytic reactor containing the heterogeneous catalyst is heated to a temperature between 250° C. and 374° C. The pressure in the catalytic reactor can be up to 23 MPa. In a preferred embodiment the catalytic reactor is operated at temperatures between 340° C. and 360° C. and pressures between 18 MPa and 21 MPa.

The purpose of the foregoing abstract is to enable the United States Patent and Trademark Office and the public generally, especially the scientists, engineers, and practitioners in the art who are not familiar with patent or legal terms or phraseology, to determine quickly from a cursory inspection the nature and essence of the technical disclosure of the application. The abstract is neither intended to define the invention of the application, which is measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

Various advantages and novel features of the present invention are described herein and will become further readily apparent to those skilled in this art from the following detailed description. In the preceding and following descriptions, the various embodiments, including the preferred embodiments, have been shown and described. Included herein is a description of the best mode contemplated for carrying out the invention. As will be realized, the invention is capable of modification in various respects without departing from the invention. Accordingly, the drawings and description of the preferred embodiments set forth hereafter are to be regarded as illustrative in nature, and not as restrictive.

DESCRIPTION OF DRAWINGS

Embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1** is a diagram depicting system for hydrothermal gasification of biomass according to one embodiment of the present invention.

DETAILED DESCRIPTION

The following description includes the preferred best mode of one embodiment of the present invention. It will be clear